

# The Future of the US Coal Industry in a Carbon Constrained World

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*laboratory  
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environment*



# Outline

- Scope of Analysis
- Methodology
- Results

# Scope of analysis

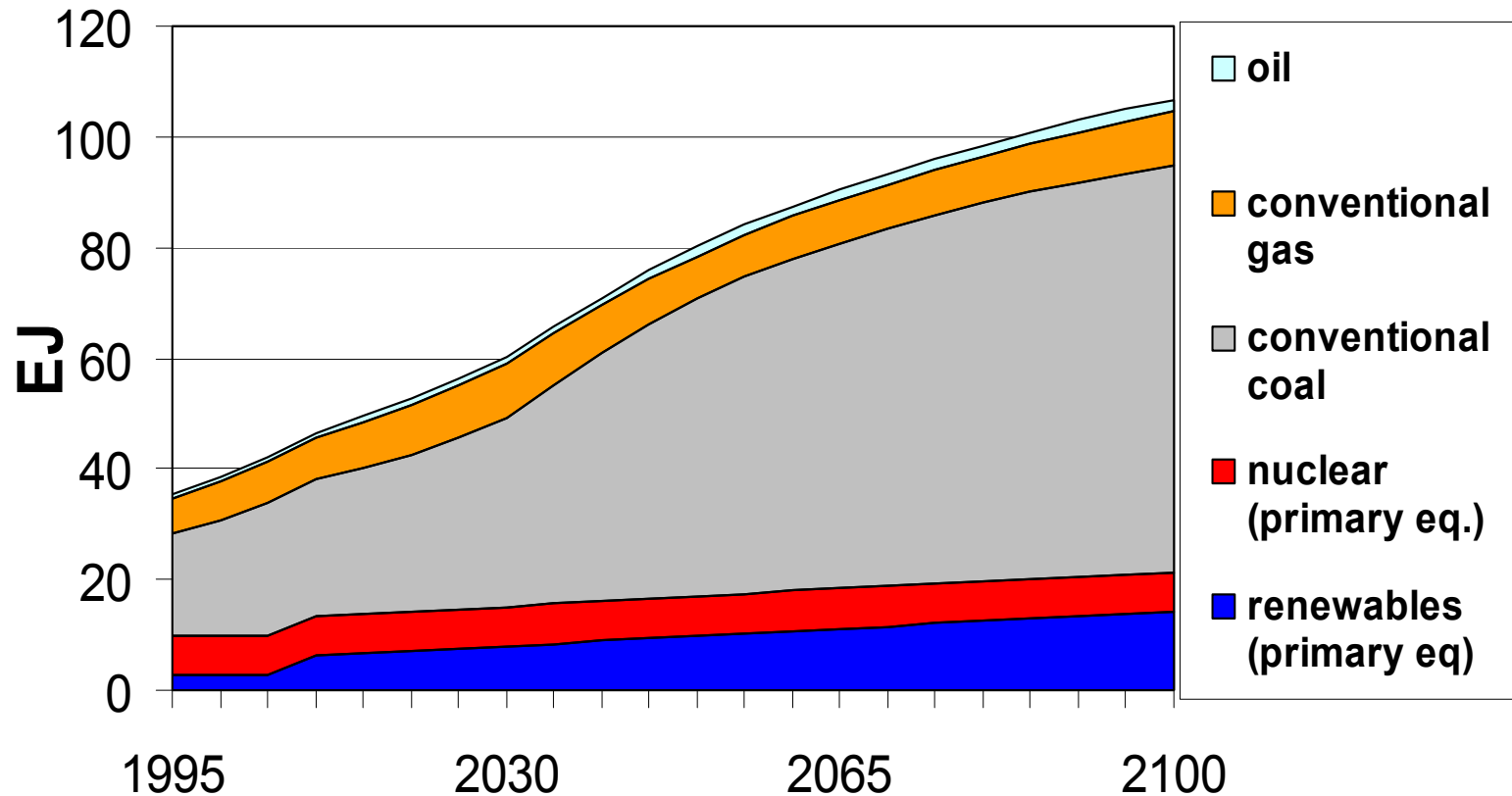
- Focus is on coal demand in the US electric sector
  - responsible for 91% of coal consumption in US
- Assess sensitivities to
  - *carbon price*
  - *natural gas price*
  - *cost of carbon capture and storage (CCS) technologies*
- Analysis emphasizes 2000-2050 timeframe
- Nuclear electricity generation remains constant throughout the modeling horizon

# Modeling framework

- MIT Emission Prediction and Policy Analysis Model (EPPA)
- General equilibrium economic model of global economy
  - 12 regions with trade
  - 5 sectors
    - Agriculture, Energy Intensive Industries, Fossil Energy Production, Other Industries and Services, Electricity
  - Endogenously determines prices and quantities in each period
- Electric sector technologies
  - Conventional fossil fuel (coal + oil + gas)
  - Nuclear, hydro, wind & solar, biomass
  - Natural gas combined cycle (NGCC)
  - Natural gas combined cycle with CCS
  - Integrated gasification combined cycle with CCS

# Primary energy in electricity generation

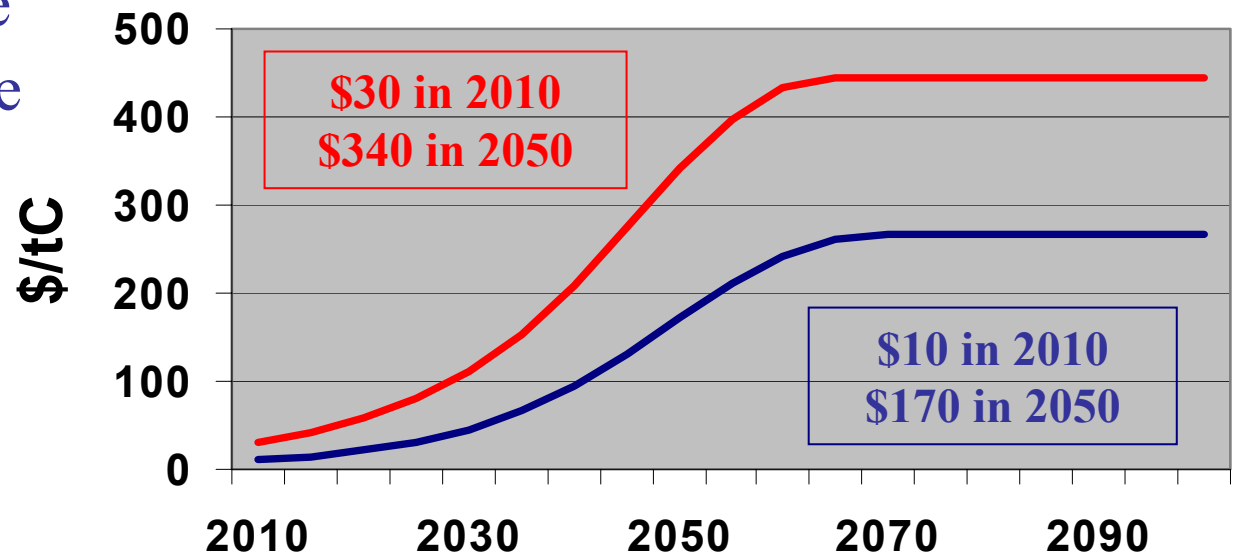
no policy, reference gas price



- Coal stays much cheaper than gas
- CCS technology is not competitive

# Carbon price paths

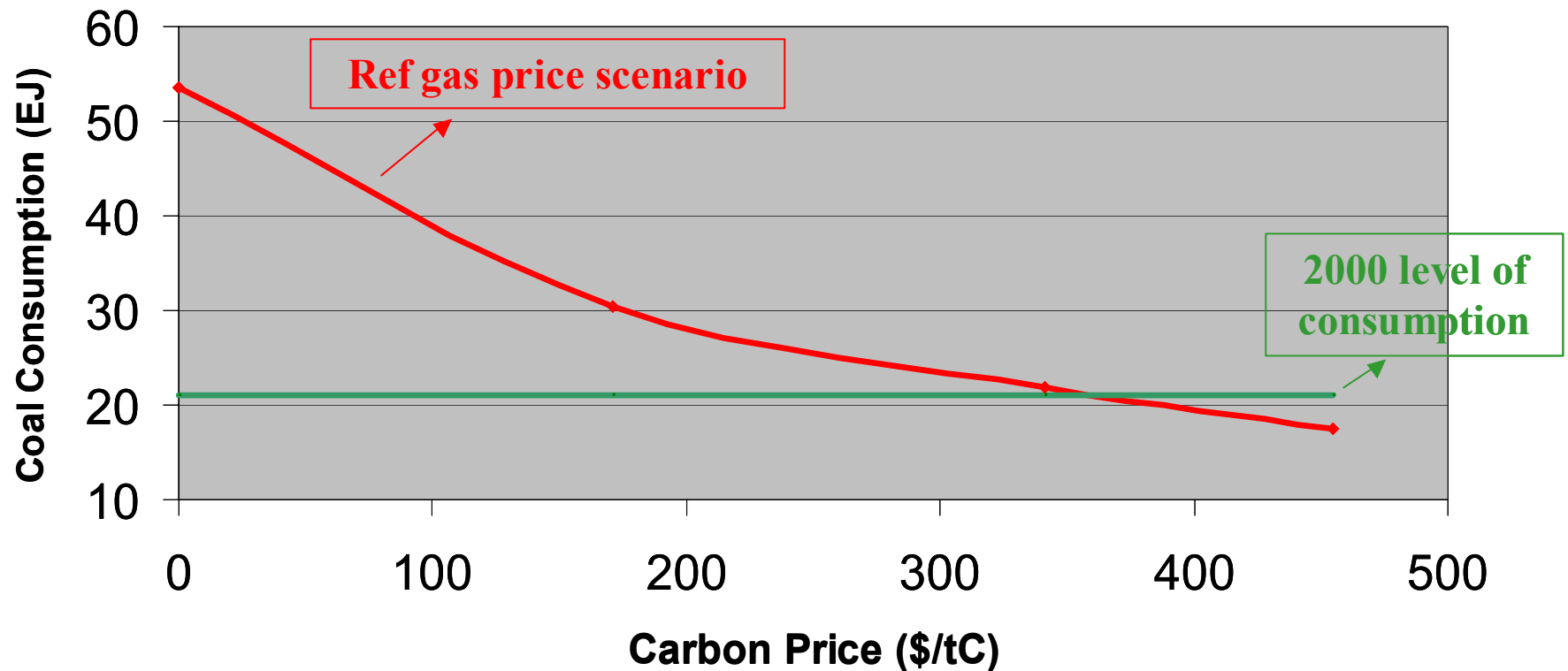
- Three simple carbon price paths:
  - No policy case
  - Low price case
  - High price case



- Politically tractable carbon price paths
- Emissions do not stabilize under either trajectory

# Influence of carbon prices on coal consumption

reference gas price, mid technology cost scenario in 2050

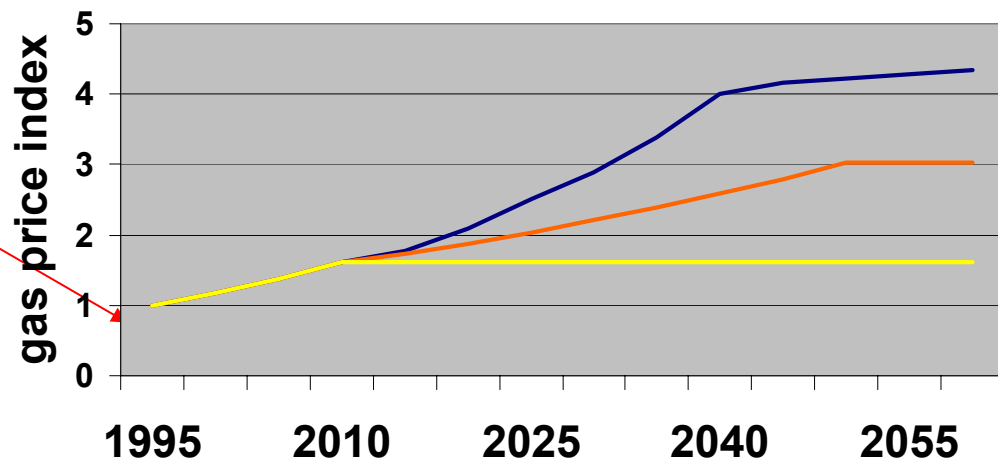


**Coal consumption is highly sensitive to carbon prices**

# Gas price paths

- Three gas price scenarios:
  - Reference gas prices (based on USGS estimates)
  - Mid gas prices
  - Low gas price (2010 level)

1995 wellhead price  
\$1.5/Mcf<sup>(1)</sup>



Price  
Index  
2050

4.2

3

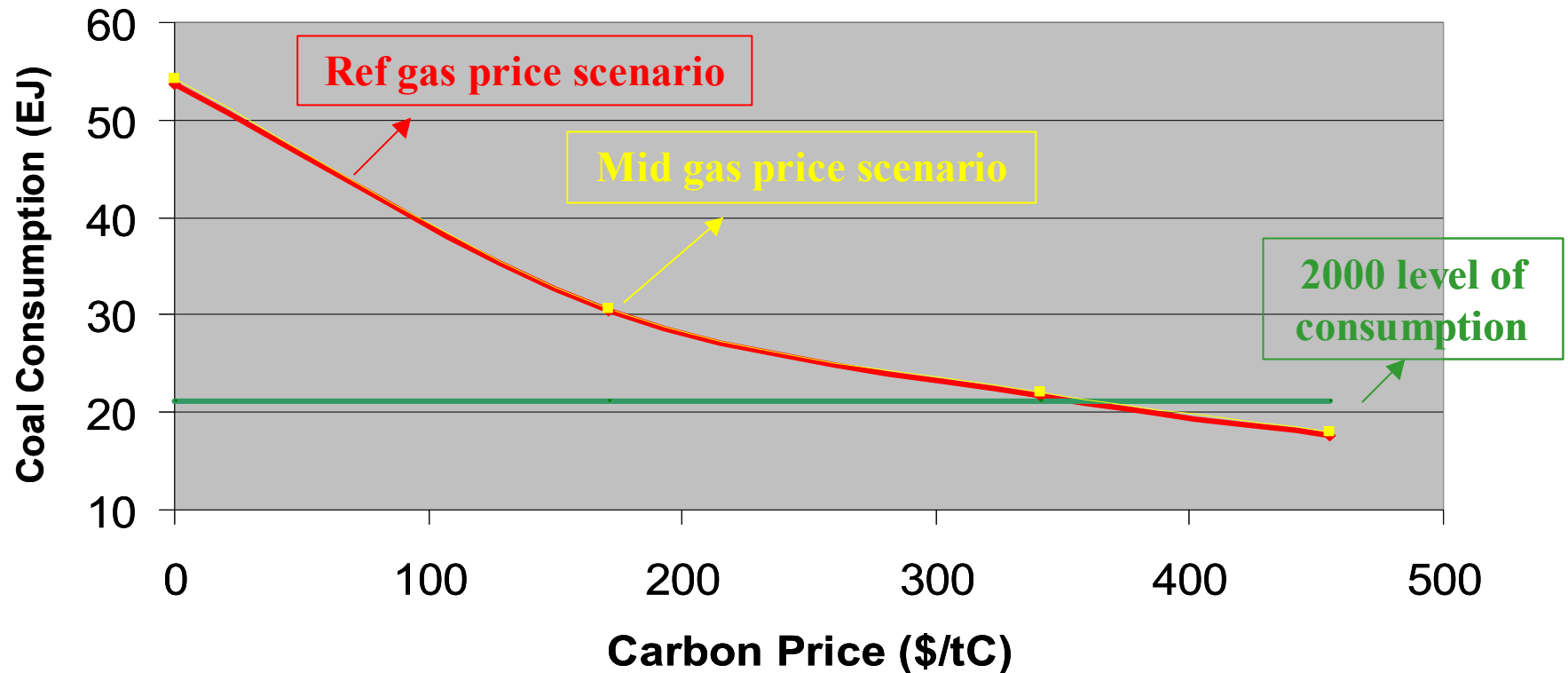
1.6

(1): 1995 average, US EIA & EPPA



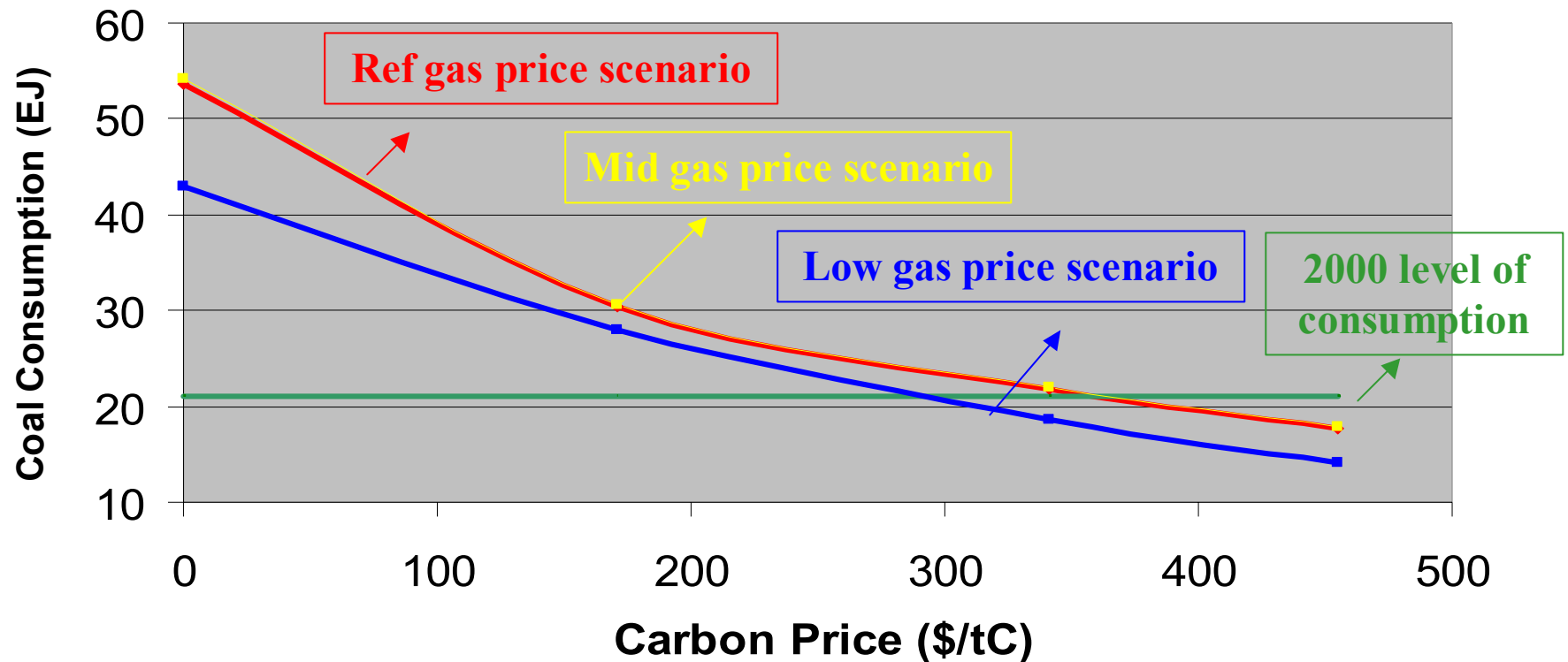
# Influence of gas prices on coal consumption

## mid technology cost scenario in 2050



# Influence of gas prices on coal consumption

## mid technology cost scenario in 2050



**Future coal consumption is more sensitive to carbon prices than gas prices over the examined ranges.**

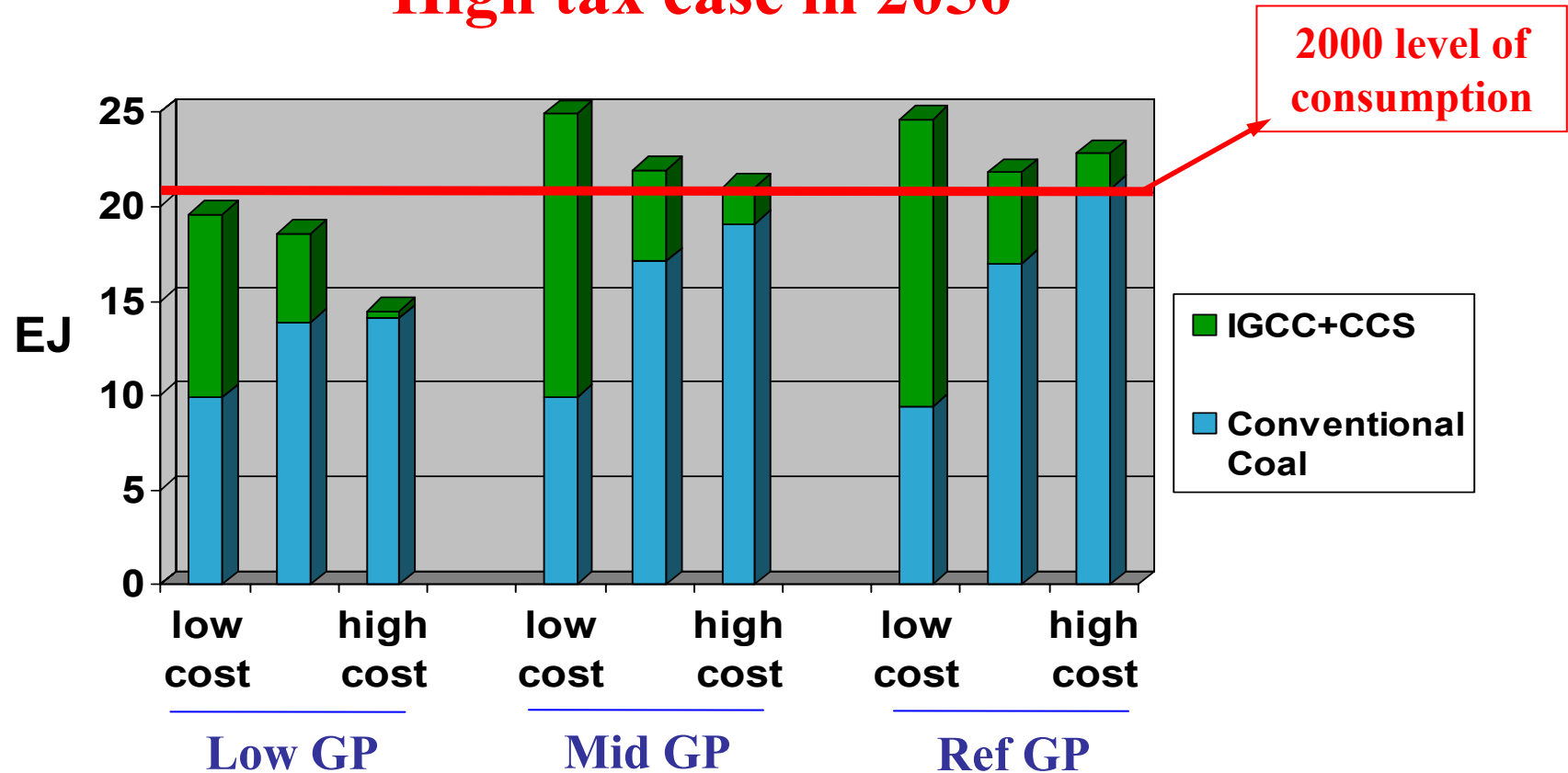
# Carbon capture and storage costs

- Based on bottom-up engineering cost models.
- Technologies are priced relative to conventional coal in 1995 (6.6 cents/kWh including transmission and distribution).
- Capture 90% efficiency.

	Technology			
Relative Costs	Coal	NGCC	NGCC+CCS	IGCC+CCS
Reference (cents/kWh)	- (6.60)	-16% (5.50)	+8% (7.10)	+26% (8.32)
Mid			+7% (7.05)	+16% (7.69)
Low			+6% (6.99)	+10% (7.24)

# Influence of costs on coal consumption

## High tax case in 2050

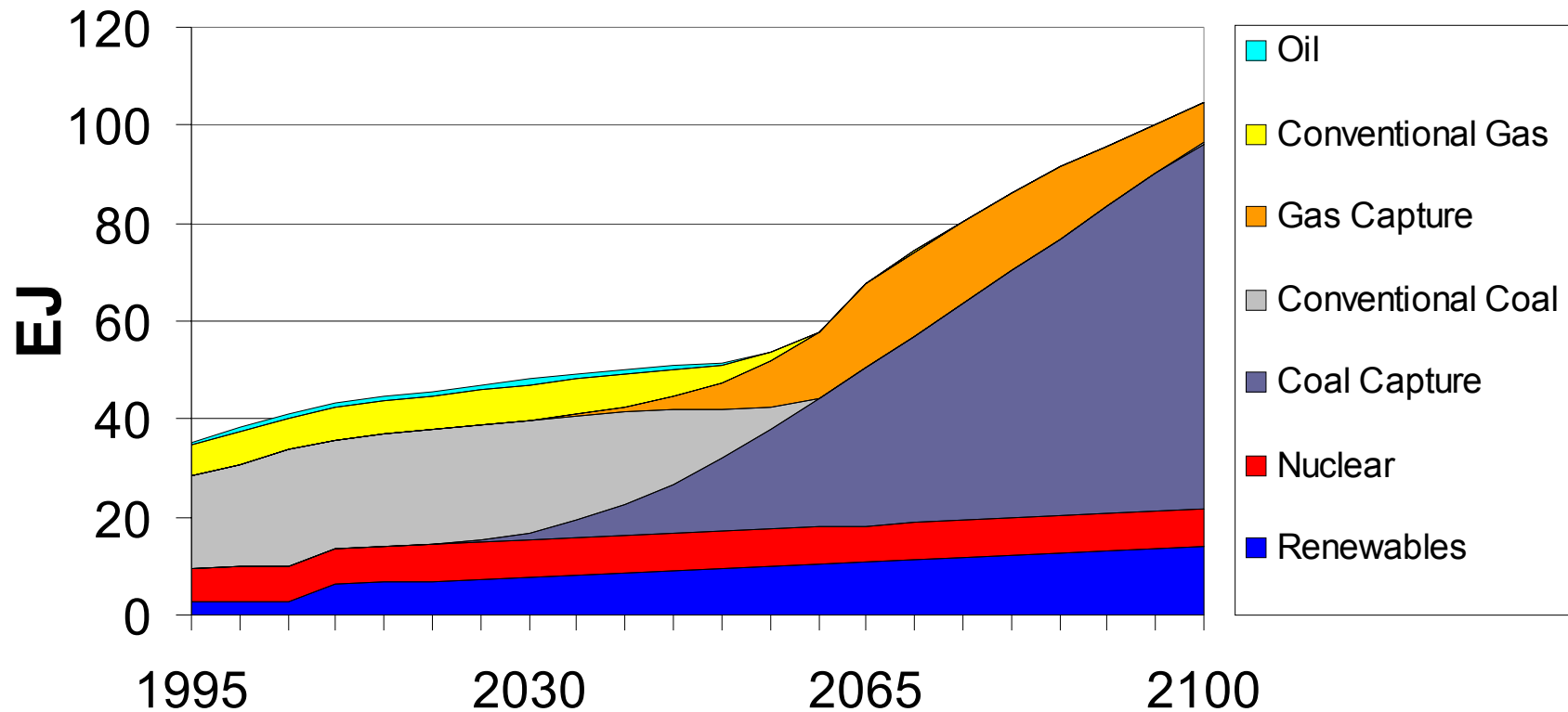


CCS cost reductions help coal, *however* consumption remains near year 2000 levels.

# Beyond 2050

# Primary energy in electricity generation

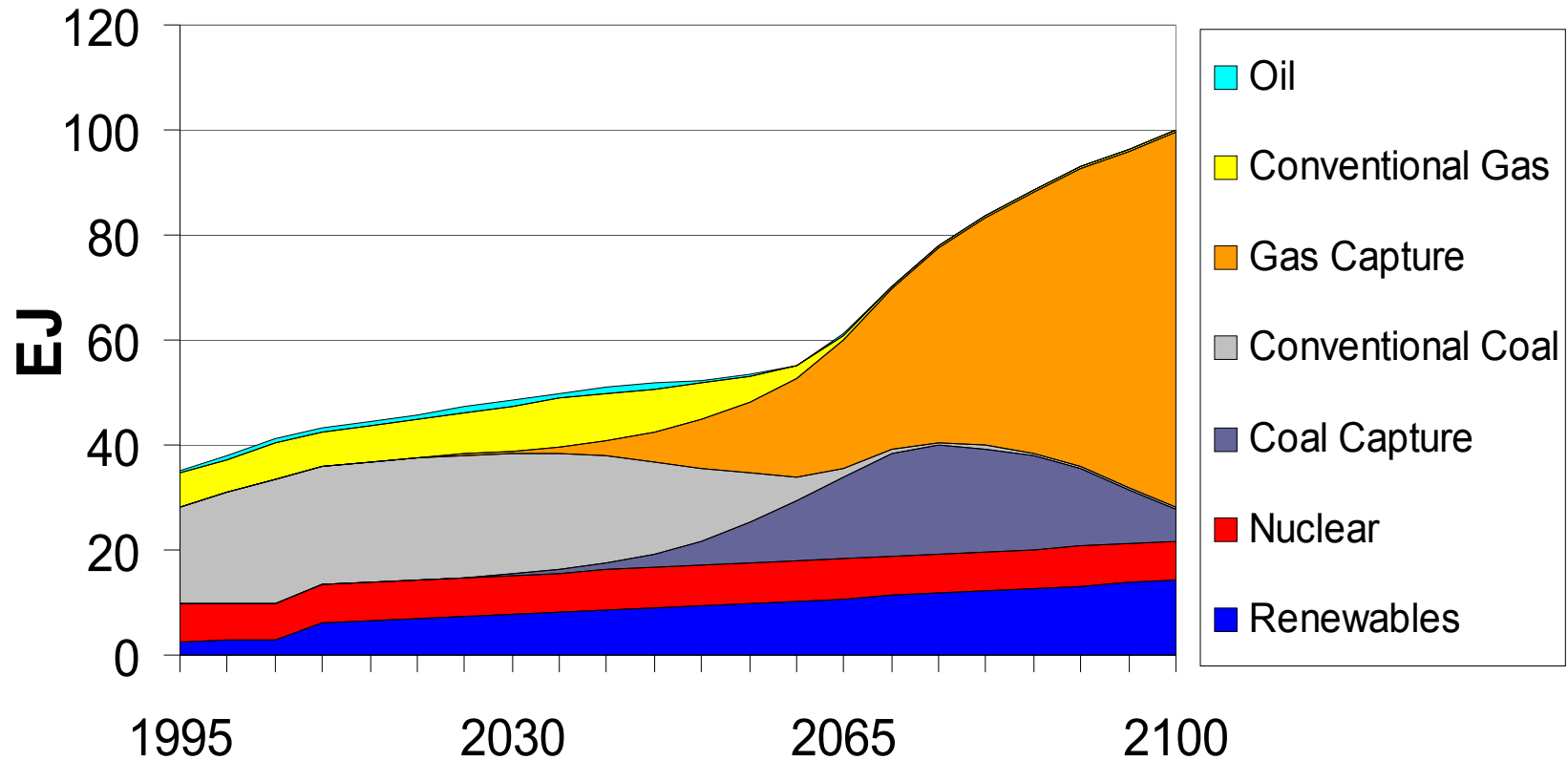
high tax, mid GP, low cost



**Under certain conditions, coal consumption reaches long-run baseline levels using capture and storage technologies.**

# Primary energy in electricity generation

high tax, low GP, mid cost



**Low long-run gas prices lead to a substantial decline in coal consumption.**

# Conclusions

## 2000-2050

- Coal demand is highly dependent upon the carbon tax.
- Coal is less sensitive to natural gas prices over the ranges examined.
- Improvements in CCS technology make coal less dependent on gas prices but do not mitigate tax effects on consumption through 2050.

## Beyond 2050

- CCS technologies may become the primary source of electricity generation.  
(caveats – nuclear, wind & solar)
- Coal dominates under:
  - mid to reference gas prices AND mid to low costs
- Gas dominates under:
  - high taxes, low gas prices AND mid to reference costs